to consider the two Woolwich forms as being variations of *Rolphii*; the peculiar form of the subcolumellar plica, and other characters, not admitting of the union of either with any other allied species. The specimen formerly in question must for the present be considered as a large and unusual variety, or accidental deviation from the general type of *Cl. Rolphii*. This deviation is particularly observable in the form of the spire, in the less-developed basal crest, and in the more narrowly rimate and contracted periomphalus. There is also no trace of the slight palatal callus, vanishing towards the base, which is observable in the ordinary form found in other English localities and on the continent.—W. H. Benson.

On the Origin of Greensand, and its Formation in the Oceans of the present Epoch. By Prof. J. W. Bailey.

As an introduction to the subject of this paper, it is proper to refer to various observations which have been made of facts intimately related to those which I wish to present. That the calcareous shells of the Polythalamia are sometimes replaced by silica, appears to have been first noticed by Ehrenberg, who, in a note translated by Mr. Weaver, and published in the Philosophical Magazine for 1841 (vol. xviii. p. 397), says:—

"I may here remark that my continued researches on the Polythalamia of the Chalk have convinced me that very frequently in the earthy coating of flints, which is partly calcareous and partly siliceous, the original calcareous-shelled animal forms have exchanged their lime for silex without undergoing any alteration in figure, so that while some are readily dissolved by an acid, others remain insoluble; but in chalk itself, all similar forms are immediately dissolved."

The first notice of *casts* of the cells and soft parts of the Polythalamia was published by myself in the 'American Journal of Science' for 1845, vol. xlviii., where I stated as follows:—

"The specimens from Fort Washington presented me with what I believe have never been before noticed, viz. distinct *casts* of Polythalamia. That these minute and perishable shells should, when destroyed by chemical changes, ever leave behind them indestructible memorials of their existence, was scarcely to be expected, yet these casts of Polythalamia are abundant and easily to be recognized in some of the Eocene marls from Fort Washington." This notice was accompanied by figures of well-defined casts of Polythalamia (*l. c.* pl. 4. fig. 30, 31).

Dr. Mantell also noticed the occurrence of casts of Polythalamia and their soft parts preserved in flint and chalk, and communicated an account of them to the Royal Society of London, in May 1846. In this paper he speaks of the chambers of Polythalamia as being frequently filled with chalk, flint, and *silicate of iron* (Phil. Trans. 1846, p. 466). To Ehrenberg, however, appears to be due the credit of first distinctly announcing the connexion between the Polythalamia and the formation of greensand, thus throwing the first light upon the origin of a substance which has long been a puzzle to

geologists. In a notice given by this distinguished observer upon the nature of the matrix of the bones of the Zeuglodon from Alabama (see Berlin Monatsbericht, February 1855), he says :—

"That greensand, in all the numerous relations in which I have as yet examined it, has been recognized as due to the filling-up of organic cells, as a formation of stony casts (Steinkernbildung) mostly of Polythalamia, was stated in July of the preceding year." He then refers to the Nummulite limestone of Traunstein in Bavaria, as rich in green opal-like casts (Opalsteinkernen) of well-preserved Polythalamian forms, and mentions them as also occurring, but more rarely, in the Glauconite limestones of France. He then proceeds to give an account of his detection of similar casts in the limestone adhering to the bones of the Zeuglodon from Alabama, and states that this limestone abounds in well-preserved brown, green, and whitish stony casts of recognizable Polythalamia. This limestone is yellowish, and under a lens appears spotted with green. These green spots are the greensand casts of Polythalamia, and they often form as much as one-third of the mass. By solution in dilute hydrochloric acid, the greensand grains are left, mixed with quartzose sand, and with a light yellowish mud. The latter is easily removed by washing and decantation. The casts thus obtained are so perfect, that not only the genus, but often the species of the Polythalamia can be recognized. Mingled with these are frequently found spiral or corkscrew-like bodies, which Ehrenberg considers as casts of the shells of young mollusks.

With reference to the perfection of these casts of the Polythalamia, and the light they throw upon the structure of these minute animals, Ehrenberg remarks :—

"The formation of the greensand consists in a gradual filling-up of the interior space of the minute bodies with a green-coloured, opal-like mass, which forms therein as a cast. It is a peculiar species of natural injection, and is often so perfect, that not only the large and coarse cells, but also the very finest canals of the cell-walls, and all their connecting tubes, are thus petrified and separately exhibited. By no artificial method can such fine and perfect injections be obtained."

Having repeated the experiments of Ehrenberg upon the Zeuglodon limestone, I can confirm his statements in every particular, and would only add, that besides the casts of Polythalamia and small spiral mollusks, there is also a considerable number of green, red, and whitish casts of minute anastomosing tubuli, resembling casts of the holes made by burrowing sponges (*Cliona*) and worms.

In the Berlin Monatsbericht for July 1855, Ehrenberg gives an account of very perfect casts of Nummulites, from Bavaria and from France, showing not only chambers connected by a spiral siphuncle, but also a complicated system of branching vessels. He also gave at the same time an account of a method he had applied for the purpose of colouring certain glass-like casts of Polythalamia, which he had found in white tertiary limestone from Java. This method consists in heating them in a solution of nitrate of iron, by

means of which they can be made to assume different shades of yellow and brownish-red, still retaining sufficient transparency when mounted in balsam to show the connexion of the different parts.

The interesting observations of Ehrenberg, which are alluded to above, have led me to examine a number of the cretaceous and tertiary rocks of North America in search of greensand and other casts of Polythalamia, &c. The following results were obtained:—

1st. The yellowish limestone of the cretaceous deposits of New Jersey, occurring with *Teredo tibialis*, &c., at Mullica Hill, and near Mount Holley, is very rich in greensand casts of Polythalamia and of the tubuliform bodies above alluded to.

2nd. Cretaceous rocks from Western Texas, for which I am indebted to Major W. H. Emory, of the Mexican Boundary Commission, yielded a considerable number of fine greensand and other casts of Polythalamia and tubuli.

3rd. Limestone from Selma, Alabama, gave similar results.

4th. Eocene limestone from Drayton Hall, near Charleston, South Carolina, gave abundance of similar casts.

5th. A few good greensand casts of Polythalamia were found in the residue left on dissolving a specimen of marl from the Artesian well at Charleston, S.C.; depth 140 feet.

6th. Abundance of organic casts, in greensand, &c., of Polythalamia, tubuli, and of the *cavities of Corals*, were found in the specimen of yellowish limestone adhering to a specimen of *Scutella Lyelli* from the Eocene of North Carolina.

7th. Similar casts of Polythalamia, tubuli, and of the *cavities of Corals*, and spines of Echini, were found abundantly in a whitish limestone adhering to a specimen of *Ostrea sellæformis* from the Eocene of South Carolina.

The last two specimens scarcely gave any indications of the presence of greensand before they were treated with dilute acid, but left an abundant deposit of it when the calcareous portions were dissolved out. All the above-mentioned specimens contained well-preserved and perfect shells of Polythalamia. It appears from the above, that the occurrence of well-defined organic casts, composed of greensand, is by no means rare in the fossil state.

I come now to the main object of this paper, which is to announce that the formation of precisely similar greensand and other casts of Polythalamia, mollusks, and tubuli, is now going on in the deposits of the present ocean. In an interesting Report by Count F. Pourtales, upon some specimens of soundings obtained by the U.S. Coast Survey in the exploration of the Gulf Stream (see Report of U.S. Coast Survey for 1853, Appendix, p. 83), the sounding, from lat. 31° 32′, long. 79° 35′, depth 150 fathoms, is mentioned as "a mixture in about equal proportions of Globigerina and black sand, probably greensand, as it makes a green mark when crushed on paper." Having examined the specimen alluded to by Count Pourtales, besides many others from the Gulf Stream and Gulf of Mexico, for which I am indebted to Prof. A. D. Bache, the Superintendent of the Coast Survey, I have found that not only is greensand present at the

above locality, but at many others, both in the Gulf Stream and Gulf of Mexico, and that this greensand is often in the form of well-defined casts of Polythalamia, minute mollusks, and branching tubuli, and that the same variety of the petrifying material is found as in the fossil casts, some being well-defined greensand, others reddish, brownish, or almost white. In some cases I have noticed a single cell, of a spiral Polythalamian cast, to be composed of greensand, while all the others were red or white, or *vice versâ*.

The species of Polythalamia whose casts are thus preserved, are easily recognizable as identical with those whose perfectly preserved shells form the chief part of the soundings. That these are of recent species is proved by the facts that some of them still retain their brilliant red colouring, and that they leave distinct remains of their soft parts when treated with dilute acids. It is not to be supposed, therefore, that these casts are of extinct species washed out of ancient submarine deposits. They are now forming in the muds as they are deposited, and we have thus now going on in the present seas, a formation of greensand by processes precisely analogous to those which produced deposits of the same material as long ago as the Silurian epoch. In this connexion, it is important to observe that Ehrenberg's observations and my own, establish the fact that *other* organic bodies than Polythalamia produce casts of greensand; and it should also be stated that many of the grains of greensand accompanying the well-defined casts are of wholly unrecognizable forms, having merely a rounded, cracked, lobed, or even coprolitic appearance. Certainly many of these masses, which often compose whole strata, were not formed either in the cavities of Polythalamia or mollusks. The fact, however, being established beyond a doubt, that greensand does form casts in the cavities of various organic bodies, there is a great probability that all the masses of this substance, however irregular, were formed in connexion with organic bodies, and that the chemical changes accompanying the decay of the organic matter have been essentially connected with the deposits in the cavities, of green and red silicates of iron, and of nearly pure silica. It is a curious fact in this connexion, that the *siliceous* organisms, such as the Diatomaceæ, Polycistineæ, and Spongiolites which accompany the Polythalamia in the Gulf Stream, do not appear to have any influence in the formation of casts.

The discovery of Prof. Ehrenberg, of the connexion between organic bodies and the formation of greensand, is of very great interest, and is one of the many instances which he has given to prove the extensive agency of the minutest beings in producing geological changes.—*Proc. Bost. Soc. Nat. Hist.* vol. v. p. 364.

On the Cumæ. By Prof. Agassiz.

In a recent number of the 'Annals and Magazine of Natural History,' Mr. Bate describes some Crustacea related to *Cumæ*, which had young, and *therefore were adults*. This is not in conflict with the statement of Prof. Agassiz in this Journal, vol. xiii. p. 426,